
Assimilation of Wind Profiles from Multiple Doppler Radar Wind Profilers for Space Launch Vehicle Applications

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Agenda

- Background
- Data Sources
- PrESTo
- Conclusion

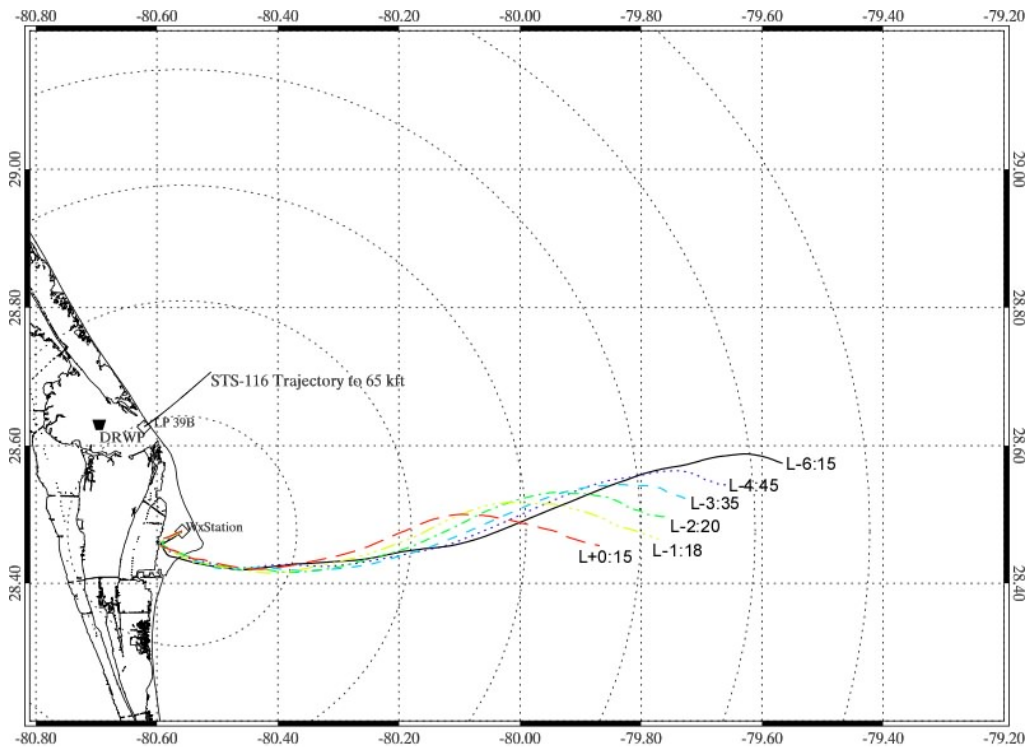


Background

- Space launch vehicles utilize atmospheric winds to assess affects of ascent structural loads and trajectory performance in design and Day of Launch (DOL) operations.
- The United States Air Force's Eastern and Western launch ranges have extensive networks of in-situ and Doppler Radar Wind Profiler (DRWP) instrumentation to measure atmospheric winds.
- Instrumentation sources have both advantages and disadvantages when applying to vehicle engineering analyses.
 - Balloons
 - Advantage – Reaches required altitudes for vehicle assessments
 - Disadvantage – Rise time and downrange drift.
 - DRWP
 - Advantage – High sample rates/continuous operation
 - Disadvantage – Limited altitude coverage.



Background - Spatial Separation in Wind Measurements



ENDING ALTITUDES

L-6:15 Jimsphere 52200 ft
L-4:45 Jimsphere 55400 ft
L-3:35 Jimsphere 54900 ft
L-2:20 Jimsphere 57800 ft
L-1:18 High Res 55000 ft
L+0:15 Jimsphere 57600 ft

Data Sources

Automated Meteorological Profiling System (AMPS)

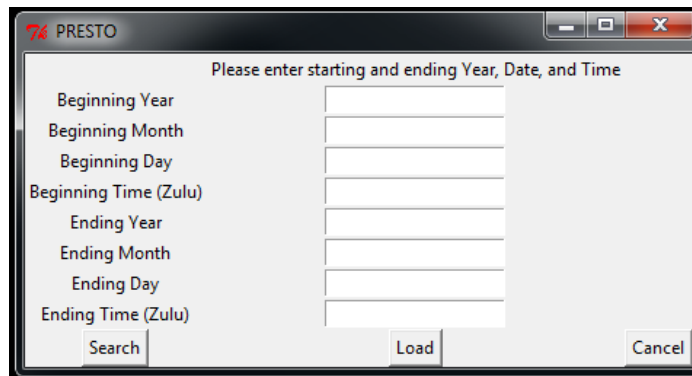
- Low Resolution Flight Element (LRFE)
 - Latex balloon
 - 1000 ft (300 m) altitude intervals
 - Typically reach 100 kft (30 km)
- High Resolution Flight Element (HRFE)
 - Specially designed, constant volume balloon (called a Jimsphere) with roughness elements to reduce balloon oscillation.
 - 100 ft (30 m) altitude intervals
 - Typically reach altitudes from 52-60 kft (16-18 km)

DRWP

- 50-MHz
 - Football field size antenna array
 - Profiles approximately every 5 minutes; 500 ft (150 m) altitude intervals
 - Altitude range 6-60 kft (2.0-18.3 km)
- 915-MHz
 - 4 panel phased array antenna.
 - Profiles approximately every 15 minutes; 328 ft (100 m) altitude intervals
 - Altitude range 0.6-10 kft (0.2-3.0 km)

PrESTo

- **Profile Envision and Splice Tool**
- Python based application using multiple modules.
- Generates a spliced profile of wind and thermodynamic parameters over user defined ranges from multiple data sources.
 - Wind speed, wind direction, wind components (u & v), temperature, pressure, and density.
 - Surface up to 600 kft (183 km).
- Allows user to select multiple profiles within a specified time range to splice together.



The screenshot shows a window titled "PRESTO" with a subtitle "Please enter starting and ending Year, Date, and Time". The window contains several input fields for specifying a time range:

- Beginning Year
- Beginning Month
- Beginning Day
- Beginning Time (Zulu)
- Ending Year
- Ending Month
- Ending Day
- Ending Time (Zulu)

At the bottom of the window, there are three buttons: "Search", "Load", and "Cancel".

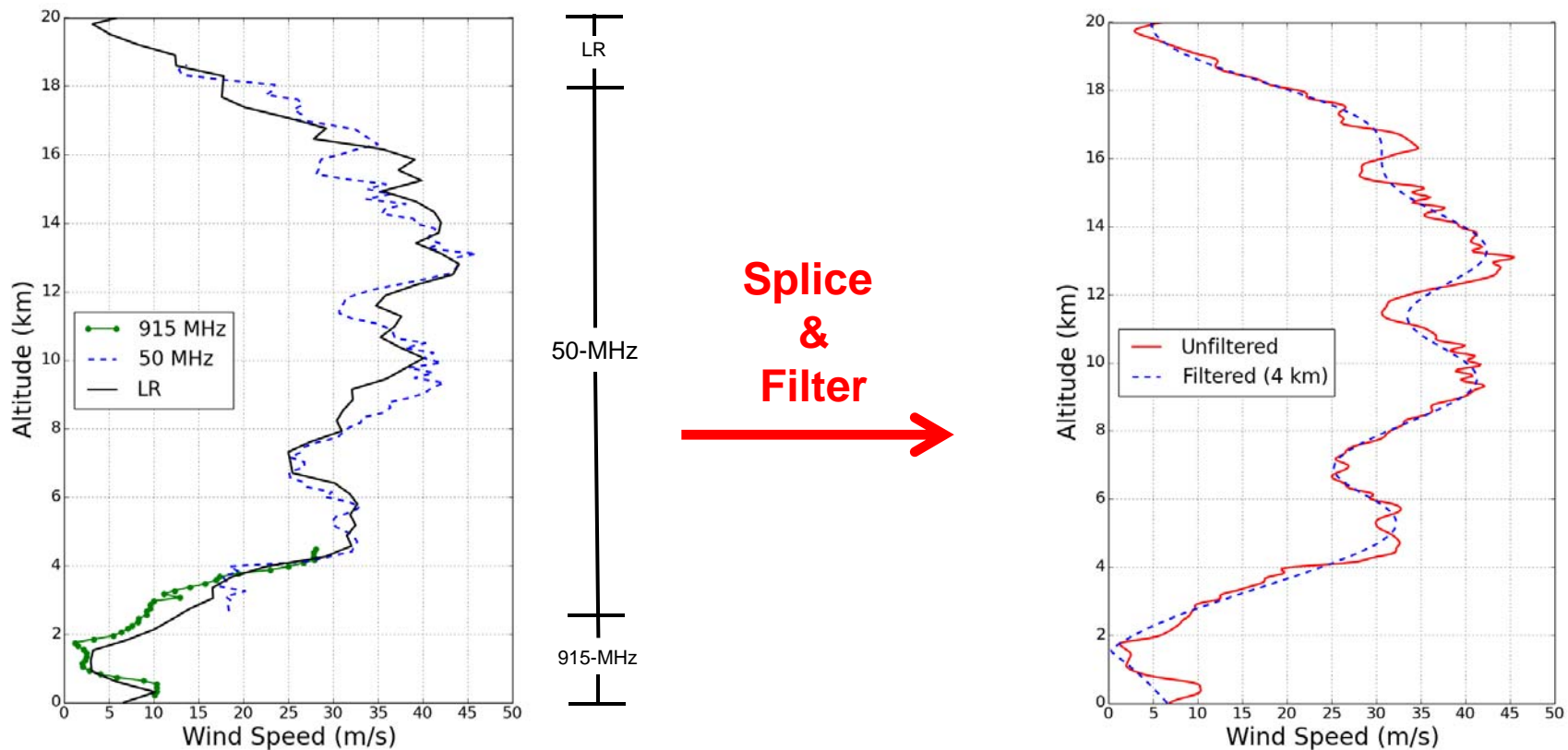
PrESTo

- Incorporates data quality control processes to remove questionable data from selected sources.
- Interpolates all the data to a constant altitude interval and range.
- From the selected sources, PrESTo searches for overlap between data.
 - If overlap exists, algorithm computes the spliced data within the overlapping region as the weighted average between the “low” and “high” profile.
 - If no overlap, algorithm interpolates the data from “low” profile to the “high” profile.

PrESTo

- Applies a common low-pass filter to remove wind component spectral content below a constant wavelength.
 - Correlated to the wavelength resolvable by the coarsest measurement systems.
- Additional low-pass filter can be applied on wind component data to remove non-persistent wind features for use in vehicle assessments.

PrESTo Example



Time correlated LRFE (1815 LST), 50- (1700 LST) and 915-MHz (1810 LST) DRWP profiles at the ER from 14 Jan. 2005 on left and the resultant spliced and spliced & filtered profiles on right.

Conclusion

- PrESTo leverages off of the advantages from both measurement systems for DOL operations.
 - DRWP systems provide high temporal resolution wind profiles.
 - Altitude coverage of the balloon-based systems.
- NASA's Space Launch System is designing the vehicle with the intention to use profile output from PrESTo in DOL trajectory design and loads evaluations.
- Anticipated completion June 2015.

